Determination of Charm Hadronic Branching Fractions at CLEO-c

A. Ryd Representing the CLEO Collaboration
Laboratory for Elementary-Particle Physics, Cornell University, Ithaca NY 14853, USA

Recent results from CLEO-c on measurements of absolute hadronic branching fractions of D^0, D^+, and D_s^+ mesons are presented.

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I. INTRODUCTION

Precise measurements of absolute hadronic branching fractions for D^0, D^+, and D_s^+ meson decays are important as they serve to normalize most B and B_s decays as well as many charm decays.

Results from the CLEO-c experiment at the Cornell Electron Positron Storage Ring based on 281 pb^{-1} recorded at the $\psi(3770)$ are presented here for studies of D^0 and D^+ decays. In addition, CLEO-c has analyzed 298 pb^{-1} of e^+e^- annihilation data near $E_{\rm cm} = 4170$ MeV for studies of D_s decays. These samples provide very clean environments for studying decays of D and D_s mesons. The $\psi(3770)$, produced in the e^+e^- annihilation, decays to pairs of D mesons, either D^+D^- or $D^0\bar{D}^0$. In particular, the produced D mesons can not be accompanied by any additional pions. At $E_{\rm cm} = 4170$ MeV D_s mesons are primarily produced as $D_s^+D_s^{*-}$ and $D_s^{*+}D_s^-$ pairs.

First, I will discuss the determination of the absolute hadronic D^0, D^+, and D_s^+ branching fractions. Then I will present CLEO-c measurements of inclusive η, η', and ϕ decays; the doubly Cabibbo suppressed decay $D^+ \to K^+\pi^0$; studies of $D \to K_S\pi$ and $D \to K_L\pi$; D_s decays to two pseudoscalars; and two-body D^0 and D^+ decays to pairs of kaons.

II. ABSOLUTE D^0 AND D^+ HADRONIC BRANCHING FRACTIONS

This analysis [1] makes use of a 'double tag' technique initially used by Mark III [2]. In this technique the yields of single tags, where one D meson is reconstructed, and double tags, where both D mesons are reconstructed, are determined. The number of reconstructed single tags, separately for D and $\bar{D}$ decays, are given by $N_i = \epsilon_i \mathcal{B}_i N_{D\bar{D}}$ and $\bar{N}_j = \bar{\epsilon}_j \mathcal{B}_j N_{D\bar{D}}$, respectively, where ϵ_i and $\mathcal{B}_i$ are the efficiency and branching fraction for mode i. Similarly, the number of double tags reconstructed are given by $N_{ij} = \epsilon_{ij} \mathcal{B}_i \mathcal{B}_j N_{D\bar{D}}$ where i and j label the D and $\bar{D}$ mode used to reconstruct the event and ϵ_{ij} is the efficiency for reconstructing the final state. Combining the equations above and solving for $N_{D\bar{D}}$ gives the number of produced $D\bar{D}$ events as

$$N_{D\bar{D}} = \frac{N_i \bar{N}_j}{N_{ij}} \frac{\epsilon_{ij}}{\epsilon_i \bar{\epsilon}_j}$$

and the branching fractions

$$\mathcal{B}_i = \frac{N_{ij}}{N_j} \frac{\epsilon_j}{\epsilon_{ij}}.$$

In this analysis we determine all the single tag and double tag yields in data, determine the efficiencies from Monte Carlo simulations of the detector response, and extract the branching fractions and $D\bar{D}$ yields from a combined fit [3] to all measured data yields.

This analysis uses three D^0 decay modes ($D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^0$, and $D^0 \to K^-\pi^+\pi^-\pi^+$) and six D^+ decay modes ($D^+ \to K^-\pi^+\pi^+$, $D^+ \to K^-\pi^+\pi^+\pi^0$, $D^+ \to K_S^0\pi^+$, $D^+ \to K_S^0\pi^+\pi^0$, $D^+ \to K_S^0\pi^+\pi^-\pi^+$, and $D^+ \to K^-K^+\pi^+$). The single tag yields are shown in Fig. 1. The combined double tag yields are shown in Fig. 2 for charged and neutral D modes separately. The scale of the statistical errors on the branching fractions are set by the number of double tags and precisions of $\approx 0.8\%$ and $\approx 1.0\%$ are obtained for the neutral and charged modes respectively. The branching fractions obtained are summarized in Table I [11]. For the branching fractions we quote three uncertainties. The first is the statistical uncertainty, the second is the systematic uncertainties excluding the uncertainty in the modeling of final state radiation (FSR), and the third error is the FSR uncertainty. For the $D^0 \to K^-\pi^+$ mode the effect of the FSR is a 3.0% correction. We have taken the uncertainty of the FSR correction to be about 30% of the correction. This covers the difference between including or excluding the effect of interference in simulating FSR in the decay $D^0 \to K^-\pi^+$.

III. ABSOLUTE BRANCHING FRACTIONS FOR HADRONIC D_s DECAYS

This analysis uses a sample of 298 pb^{-1} of data recorded at a center-of-mas energy of 4170 MeV. At this energy D_s mesons are produced, predominantly, as $D_s^+D_s^{*-}$ or $D_s^-D_s^{*+}$ pairs. We use the same tagging technique as for the hadronic D branching fractions; we reconstruct samples of single tags and double tags and use this to extract the branching fractions.

In this study eight D_s final states are used ($D_s^+ \to K_S^0K^+$, $D_s^+ \to K^+K^-\pi^+$, $D_s^+ \to K^+K^-\pi^+\pi^0$, $D_s^+ \to K_S^0K^-\pi^+\pi^+$, $D_s^+ \to \pi^+\pi^-\pi^+$, $D_s^+ \to \eta\pi^+$, $D_s^+ \to \eta'\pi^+$, and $D_s^+ \to K^+\pi^-\pi^+$). The single tag
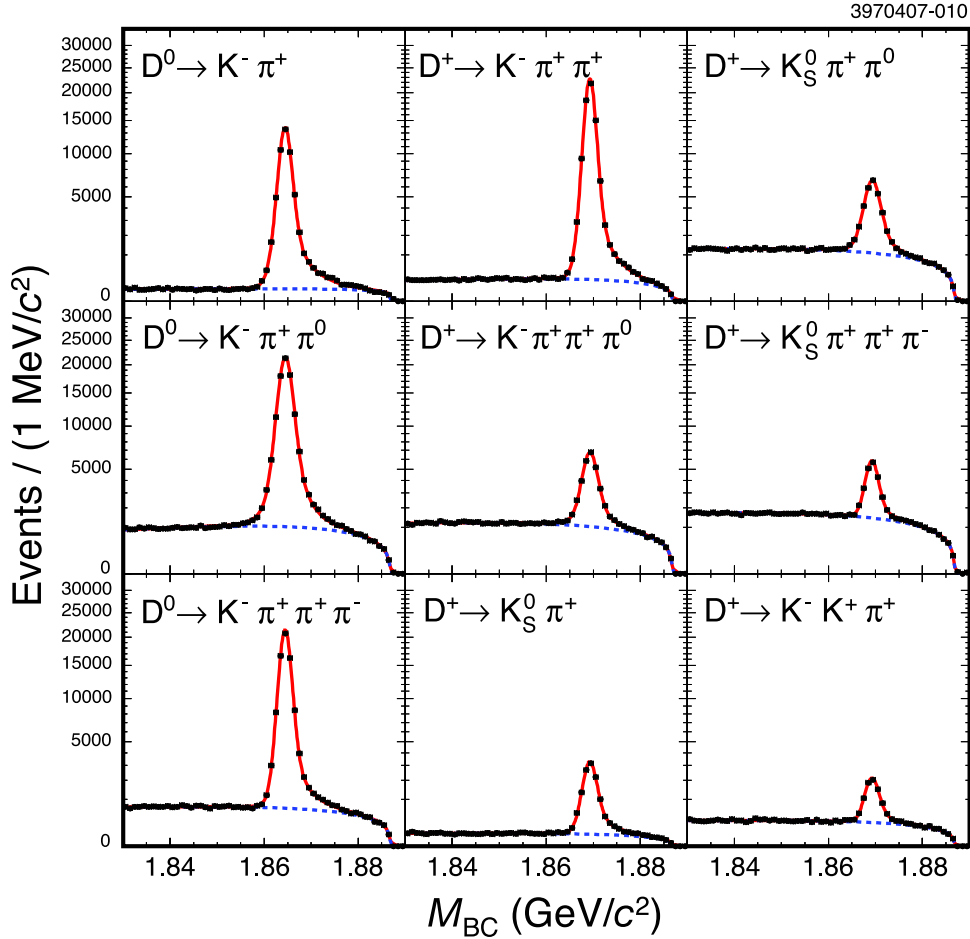
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FIG. 1: The fits for the single tag yields. The background is described by the ARGUS threshold function and the signal shape includes the effects of beam energy spread, momentum resolution, initial state radiation, and the $\psi(3770)$ lineshape.

event yields are shown in Fig. 3. The double tag yields are extracted by a cut-and-count procedure in the plot of the invariant mass of the D_s^+ vs. D_s^-. This plot is shown in Fig. 4. Backgrounds are subtracted from the sidebands indicated in the plot and a total of 976 ± 33 double tag events are found.

From these yields we determine the preliminary branching fractions listed in Table II. We do not quote branching fractions for $D_s^+ \to \phi\pi^+$ as the ϕ signal is not well defined. In particular, the ϕ resonance interferes with the f_0 resonance. Instead we report preliminary results for partial branching fractions for $D_s^+ \to K^+K^-\pi^+$ in restricted invariant mass ranges of m_{KK} near the ϕ resonance. These partial branching fractions are summarized in Table III.

IV. INCLUSIVE MEASUREMENTS OF η, η', AND ϕ PRODUCTION IN D AND D_s DECAYS

Using samples of tagged D and D_s decays CLEO-c has measured the inclusive production of η, η', and ϕ mesons by looking at the recoil against the tag [4]. The results are summarized in Table IV. The knowledge of inclusive measurements before this CLEO-c measurement was poor, besides limits, only $\mathcal{B}(D^0 \to \phi X) = (1.7 \pm 0.8)\%$ was measured. As expected the η, η', and ϕ rates are much higher in D_s decays.

V. THE DOUBLY CABIBBO SUPPRESSED DECAY $D^+ \to K^+\pi^0$

CLEO-c [5] has reconstructed $D^+ \to K^+\pi^0$ candidates in the 281 pb^{-1} sample of e^+e^- data recorded at the $\psi(3770)$. We find the branching fraction $\mathcal{B}(D^+ \to$
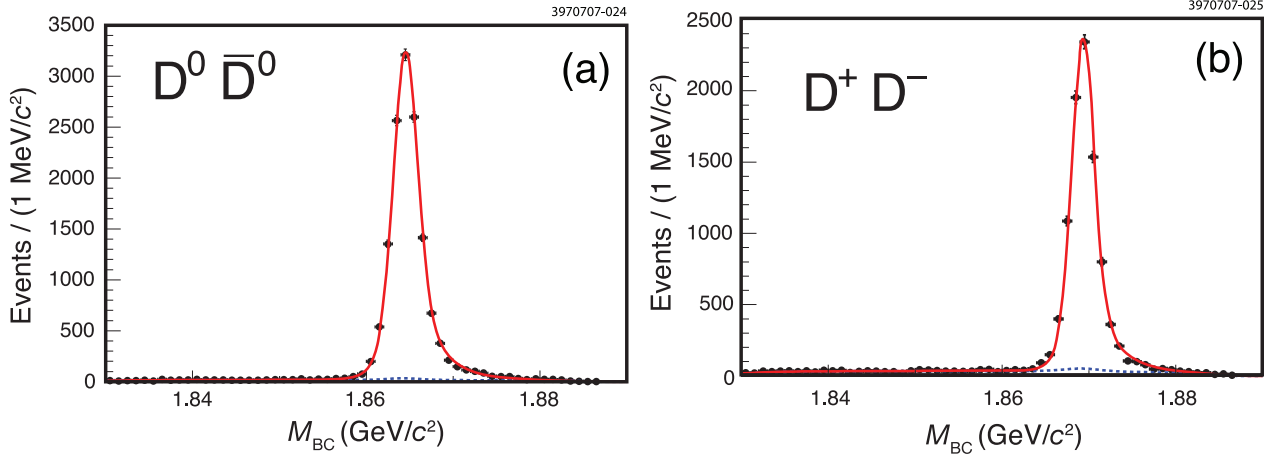
FIG. 2: The fit for the double tag yields combined over all modes for charged and neutral modes separately.

TABLE I: Fitted branching fractions and $D\overline{D}$ pair yields. For $N_{D^0\overline{D}^0}$ and $N_{D^+D^-}$, uncertainties are statistical and systematic, respectively. For branching fractions and ratios, the systematic uncertainties are divided into the contribution from FSR (third uncertainty) and all others combined (second uncertainty). The column of fractional systematic errors combines all systematic errors, including FSR. The last column, Δ_{FSR}, is the relative shift in the fit results when FSR is not included in the Monte Carlo simulations used to determine efficiencies.

Parameter	Fitted Value	Fractional Error		Δ_{FSR}
		Stat.(%)	Syst.(%)	(%)
$N_{D^0\overline{D}^0}$	$(1.031 \pm 0.008 \pm 0.013) \times 10^6$	0.8	1.3	$+0.1$
$\mathcal{B}(D^0 \to K^-\pi^+)$	$(3.891 \pm 0.035 \pm 0.059 \pm 0.035)\%$	0.9	1.8	-3.0
$\mathcal{B}(D^0 \to K^-\pi^+\pi^0)$	$(14.57 \pm 0.12 \pm 0.38 \pm 0.05)\%$	0.8	2.7	-1.1
$\mathcal{B}(D^0 \to K^-\pi^+\pi^+\pi^-)$	$(8.30 \pm 0.07 \pm 0.19 \pm 0.07)\%$	0.9	2.4	-2.4
$N_{D^+D^-}$	$(0.819 \pm 0.008 \pm 0.010) \times 10^6$	1.0	1.2	$+0.1$
$\mathcal{B}(D^+ \to K^-\pi^+\pi^+)$	$(9.14 \pm 0.10 \pm 0.16 \pm 0.07)\%$	1.1	1.9	-2.3
$\mathcal{B}(D^+ \to K^-\pi^+\pi^+\pi^0)$	$(5.98 \pm 0.08 \pm 0.16 \pm 0.02)\%$	1.3	2.8	-1.0
$\mathcal{B}(D^+ \to K^0_S\pi^+)$	$(1.526 \pm 0.022 \pm 0.037 \pm 0.009)\%$	1.4	2.5	-1.8
$\mathcal{B}(D^+ \to K^0_S\pi^+\pi^0)$	$(6.99 \pm 0.09 \pm 0.25 \pm 0.01)\%$	1.3	3.5	-0.4
$\mathcal{B}(D^+ \to K^0_S\pi^+\pi^+\pi^-)$	$(3.122 \pm 0.046 \pm 0.094 \pm 0.019)\%$	1.5	3.0	-1.9
$\mathcal{B}(D^+ \to K^+K^-\pi^+)$	$(0.935 \pm 0.017 \pm 0.024 \pm 0.003)\%$	1.8	2.6	-1.2
$\mathcal{B}(D^0 \to K^-\pi^+\pi^0)/\mathcal{B}(K^-\pi^+)$	$3.744 \pm 0.022 \pm 0.093 \pm 0.021$	0.6	2.6	$+1.9$
$\mathcal{B}(D^0 \to K^-\pi^+\pi^+\pi^-)/\mathcal{B}(K^-\pi^+)$	$2.133 \pm 0.013 \pm 0.037 \pm 0.002$	0.6	1.7	$+0.5$
$\mathcal{B}(D^+ \to K^-\pi^+\pi^+\pi^0)/\mathcal{B}(K^-\pi^+\pi^+)$	$0.654 \pm 0.006 \pm 0.018 \pm 0.003$	0.9	2.7	$+1.4$
$\mathcal{B}(D^+ \to K^0_S\pi^+)/\mathcal{B}(K^-\pi^+\pi^+)$	$0.1668 \pm 0.0018 \pm 0.0038 \pm 0.0003$	1.1	2.3	$+0.5$
$\mathcal{B}(D^+ \to K^0_S\pi^+\pi^0)/\mathcal{B}(K^-\pi^+\pi^+)$	$0.764 \pm 0.007 \pm 0.027 \pm 0.005$	0.9	3.5	$+2.0$
$\mathcal{B}(D^+ \to K^0_S\pi^+\pi^+\pi^-)/\mathcal{B}(K^-\pi^+\pi^+)$	$0.3414 \pm 0.0039 \pm 0.0093 \pm 0.0004$	1.1	2.7	$+0.4$
$\mathcal{B}(D^+ \to K^+K^-\pi^+)/\mathcal{B}(K^-\pi^+\pi^+)$	$0.1022 \pm 0.0015 \pm 0.0022 \pm 0.0004$	1.5	2.2	$+1.1$

$K^+\pi^0) = (2.24 \pm 0.36 \pm 0.15 \pm 0.08) \times 10^{-4}$, which is in good agreement with the recent BABAR measurement [6] $\mathcal{B}(D^+ \to K^+\pi^0) = (2.52 \pm 0.46 \pm 0.24 \pm 0.08) \times 10^{-4}$.

VI. MODES WITH K^0_L OR K^0_S IN THE FINAL STATES

It has commonly been assumed that $\Gamma(D \to K^0_S X) = \Gamma(D \to K^0_L X)$. However, as pointed out by Bigi and Yamamoto [7] this is not generally true as for many D decays there are contributions from Cabibbo favored and Cabibbo suppressed decays that interfere and contributes differently to final states with K^0_S and
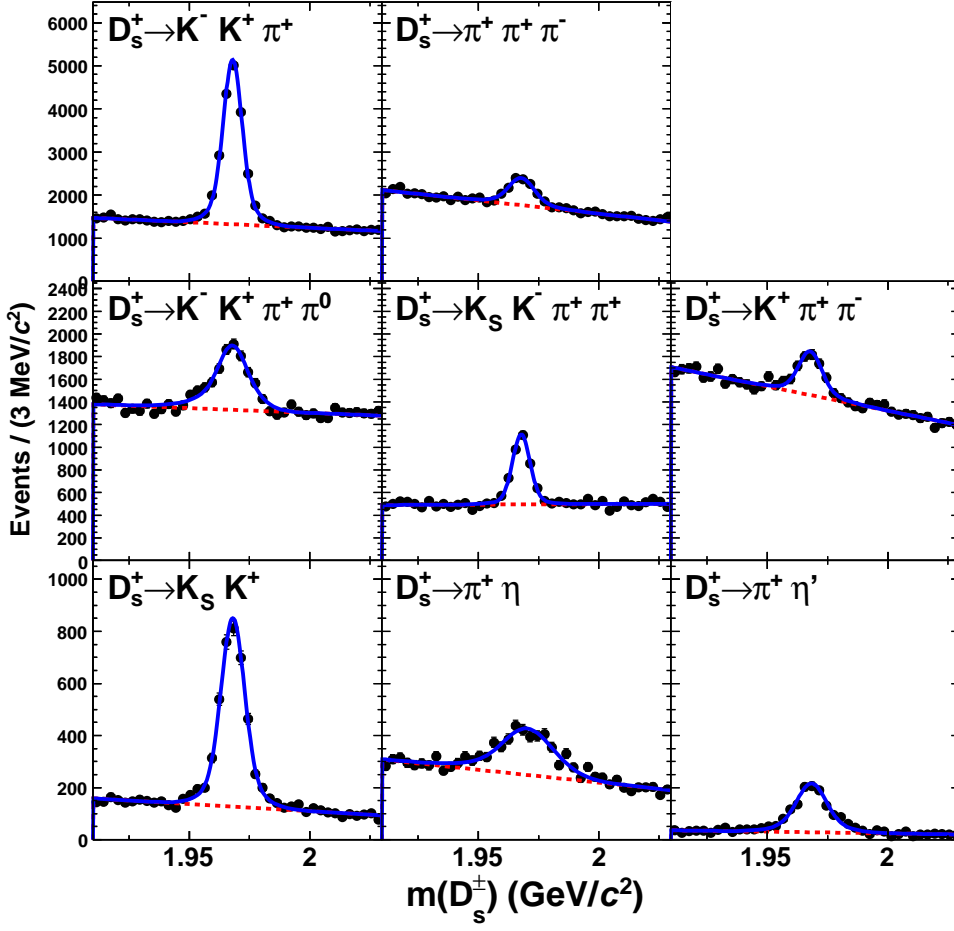
FIG. 3: Single tag yields for the reconstucted D_s modes used in the analysis of the absolute hadronic D_s branching fractions.

TABLE II: Preliminary branching fractions for D_s decays determined in the CLEO-c analysis.

| Mode	Branching Fraction (%)	PDG 2006 fit (%)
$\mathcal{B}(D_s^+ \to K_S^0 K^+)$	$1.56 \pm 0.08 \pm 0.05$	2.2 ± 0.45
$\mathcal{B}(D_s^+ \to K^+ K^- \pi^+)$	$5.67 \pm 0.24 \pm 0.18$	5.2 ± 0.9
$\mathcal{B}(D_s^+ \to K^+ K^- \pi^+ \pi^0)$	$5.58 \pm 0.29 \pm 0.45$	
$\mathcal{B}(D_s^+ \to K_S^0 K^- \pi^+ \pi^+)$	$1.73 \pm 0.10 \pm 0.07$	2.65 ± 0.7
$\mathcal{B}(D_s^+ \to \pi^+ \pi^- \pi^+)$	$1.13 \pm 0.07 \pm 0.05$	1.22 ± 0.23
$\mathcal{B}(D_s^+ \to \eta \pi^+)$	$1.63 \pm 0.11 \pm 0.17$	2.11 ± 0.35
$\mathcal{B}(D_s^+ \to \eta' \pi^+)$	$3.98 \pm 0.26 \pm 0.32$	4.5 ± 0.7
$\mathcal{B}(D_s^+ \to K^+ \pi^+ \pi^-)$	$0.71 \pm 0.05 \pm 0.03$	0.66 ± 0.14

K_L^0. As an example consider $D^0 \to K_{S,L}^0 \pi^0$. Contributions to these final states involve the Cabibbo favored decay $D^0 \to \bar{K}^0 \pi^0$ as well as the Cabibbo suppressed decay $D^0 \to K^0 \pi^0$. However, we don't observe the K^0 and the $\bar{K}^0$ but rather the K_S^0 and the K_L^0. As these two amplitudes interfere constructively to form the K_S^0 final state we will see a rate asym-metry. Based on factorization Bigi and Yamamoto predicted

$$R(D^0) \equiv \frac{\Gamma(D^0 \to K_S^0 \pi^0) - \Gamma(D^0 \to K_L^0 \pi^0)}{\Gamma(D^0 \to K_S^0 \pi^0) + \Gamma(D^0 \to K_L^0 \pi^0)}$$

$$\approx 2 \tan^2 \theta_C \approx 0.11.$$

TABLE III: Preliminary partial branching fractions for $D_s^+ \to K^+K^-\pi^+$ in limited $m(K^-K^+)$ ranges around the $\phi(1020)$ mass.

$m(K^-K^+)$ range	Partial branching fraction(%)
$\|m(K^-K^+) - m_\phi\| < \;\; 5$ MeV	$1.75 \pm 0.08 \pm 0.06$
$\|m(K^-K^+) - m_\phi\| < 10$ MeV	$2.07 \pm 0.10 \pm 0.05$
$\|m(K^-K^+) - m_\phi\| < 15$ MeV	$2.22 \pm 0.11 \pm 0.06$
$\|m(K^-K^+) - m_\phi\| < 20$ MeV	$2.32 \pm 0.11 \pm 0.06$
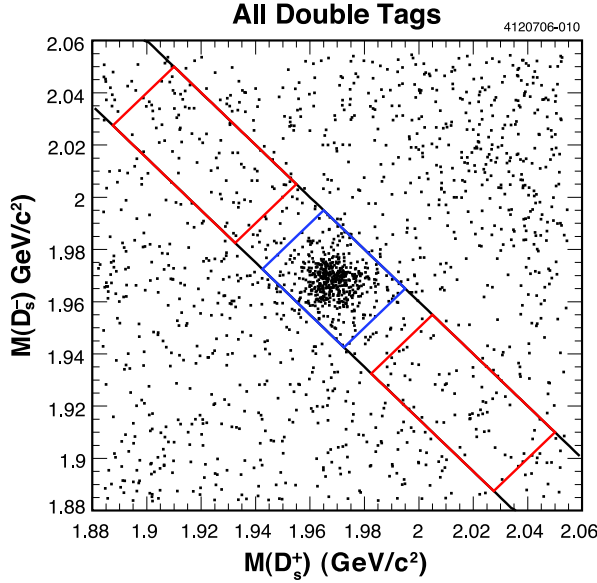
FIG. 4: The distribution of the reconstructed invariant mass of the D_s^- candidate versus the D_s^+ candidate for the double tag candidates in the absolute D_s hadronic branching fraction analysis.

Using tagged D mesons CLEO-c has measured [8] this asymmetry and obtained

$$R(D^0) = 0.108 \pm 0.025 \pm 0.024,$$

which is in good agreement with the prediction.

Similarly, CLEO-c has also measured the corresponding asymmetry in charged D mesons and obtained

$$R(D^+) \equiv \frac{\Gamma(D^+ \to K_S^0\pi^+) - \Gamma(D^+ \to K_L^0\pi^+)}{\Gamma(D^+ \to K_S^0\pi^+) + \Gamma(D^+ \to K_L^0\pi^+)}$$
$$= 0.022 \pm 0.016 \pm 0.018.$$

Prediction of the asymmetry in charged D decays is more involved. D.-N. Gao [9] predicts this asymmetry to be in the range 0.035 to 0.044, which is consistent with the observed asymmetry.

TABLE IV: Inclusive branching fractions of D^0, D^+ and D_s^+ meson decays to η, η', and ϕ.

Decay	$\mathcal{B}$ (%)
$D^0 \to \eta X$	$9.5 \pm 0.4 \pm 0.8$
$D^- \to \eta X$	$6.3 \pm 0.5 \pm 0.5$
$D_s^+ \to \eta X$	$23.5 \pm 3.1 \pm 2.0$
$D^0 \to \eta' X$	$2.48 \pm 0.17 \pm 0.21$
$D^- \to \eta' X$	$1.04 \pm 0.16 \pm 0.09$
$D_s^+ \to \eta' X$	$8.7 \pm 1.9 \pm 1.1$
$D^0 \to \phi X$	$1.05 \pm 0.08 \pm 0.07$
$D^- \to \phi X$	$1.03 \pm 0.10 \pm 0.07$
$D_s^+ \to \phi X$	$16.1 \pm 1.2 \pm 1.1$

VII. D_s DECAYS TO TWO PSEUDOSCALARS

CLEO-c has performed a study of D_s decays to a pair of pseudoscalars. These final states consists of either a K^+ or a π^+ and one of η, η', π^0, or K_S^0. In the analysis presented here the following final states are studied: $D_s^+ \to K^+\eta$, $D_s^+ \to K^+\eta'$, $D_s^+ \to K^+\pi^0$ $D_s^+ \to \pi^+K_S^0$, and $D_s^+ \to \pi^+\pi^0$. The final state $D_s^+ \to \pi^+\pi^0$ violates isospin and is expected to be small. The details of the analysis can be found in Ref. [10]. The signals are observed in the D_s invariant mass distribution as peaks at the D_s mass. Significant signals are observed in all modes except $D_s^+ \to \pi^+\pi^0$. The observed mass distributions are shown in Fig. 5. We measure the ratio of the branching fractions of the Cabibbo suppressed modes with respect to the Cabibbo favored modes. The results are summarized in Table V. The observed ratios of branching fractions are consistent with the naive expectation of $|V_{cd}/V_{cs}|^2 \approx 0.05$. In addition, we have looked for a CP asymmetry in rate for D_s^+ and D_s^- decays. No evidence for any CP asymmetry was found; the results are summarized in Table VI.

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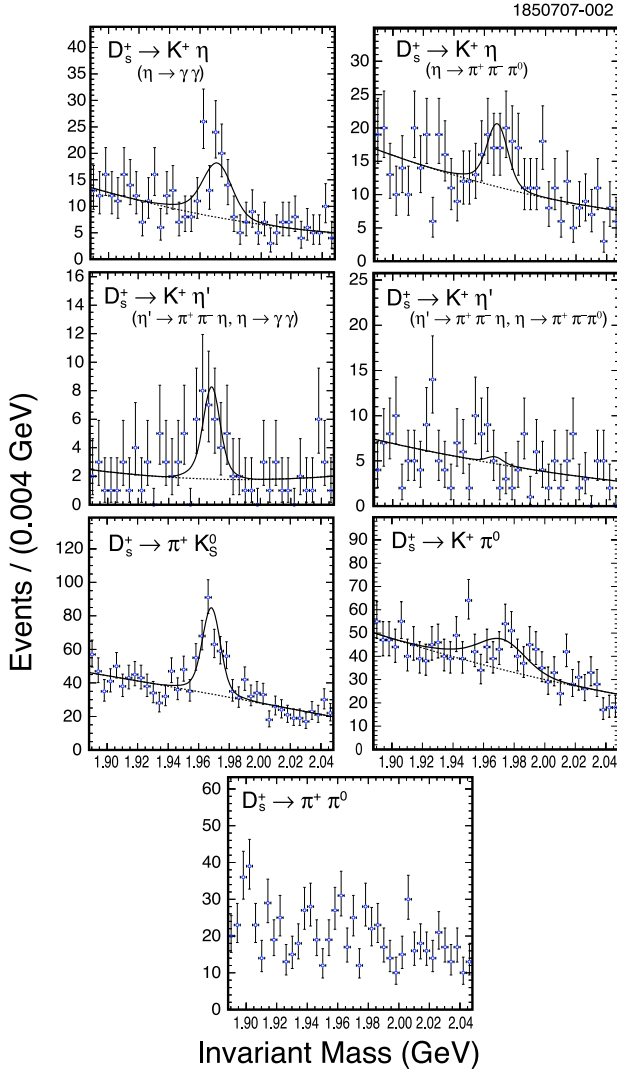
FIG. 5: Observed signals in the $D_s \to PP$ analysis.

TABLE V: Branching ratios for the $D_s \to PP$ analysis.

Mode	$\mathcal{B}_S/\mathcal{B}_F$ (%)
$\mathcal{B}(D_s^+ \to K^+\eta)/\mathcal{B}(D_s^+ \to \pi^+\eta)$	$8.9 \pm 1.5 \pm 0.4$
$\mathcal{B}(D_s^+ \to K^+\eta')/\mathcal{B}(D_s^+ \to \pi^+\eta')$	$4.2 \pm 1.3 \pm 0.3$
$\mathcal{B}(D_s^+ \to \pi^+K_S^0)/\mathcal{B}(D_s^+ \to K^+K_S^0)$	$8.2 \pm 0.9 \pm 0.2$
$\mathcal{B}(D_s^+ \to K^+\pi^0)/\mathcal{B}(D_s^+ \to K^+K_S^0)$	$5.0 \pm 1.2 \pm 0.6$
$\mathcal{B}(D_s^+ \to \pi^+\pi^0)/\mathcal{B}(D_s^+ \to K^+K_S^0)$	< 4.1 (90% CL)

VIII. D^0 AND D^+ DECAYS TO TWO KAONS

CLEO-c has studied Cabibbo suppressed two-body decays of D^0 and D^+ mesons to a pair of kaons. In

particular, the decays $D^0 \to K^-K^+$, $D^0 \to K_S^0K_S^0$, and $D^+ \to K^+K_S^0$ have been analyzed. In addition to

TABLE VI: CP asymmetries for Cabibbo suppressed $D_s \to PP$ decays.

Mode	$(\mathcal{B}_+ - \mathcal{B}_-)/(\mathcal{B}_+ + \mathcal{B}_-)$ (%)
$\mathcal{A}(D_s^+ \to K^+\eta)$	-20 ± 18
$\mathcal{A}(D_s^+ \to K^+\eta')$	-17 ± 37
$\mathcal{A}(D_s^+ \to \pi^+K_S^0)$	27 ± 11
$\mathcal{A}(D_s^+ \to K^+\pi^0)$	2 ± 29

being Cabibbo suppressed, the $D^0 \to K_S^0K_S^0$ mode is strongly suppressed due to destructive interference in the SU(3) limit between the two dominating exchange amplitudes for this decay. Figure 6 shows the observed yields in the three channels studied in this analysis.

The preliminary branching fractions are summarized in Table VII. For $D^0 \to K^+K^-$ and $D^+ \to K^+K_S^0$ there is good agreement with previous measurements. However, for $D^0 \to K_S^0K_S^0$ our new measurement is lower than previous measurements.

IX. SUMMARY

I have presented results based on 281 pb^{-1} of e^+e^- annihilation data recorded at the $\psi(3770)$ resonance for studies of D^0 and D^+ decays. Among the results presented here were the final results for the absolute $D^0 \to K^-\pi^+$ and $D^+ \to K^-\pi^+\pi^+$ branching fractions. CLEO-c has also analyzed 298 pb^{-1} of e^+e^- annihilation data recorded at the center-of-mass energy of 4170 MeV. Here we have studied the absolute hadronic branching fractions of D_s mesons. CLEO-c has recorded more than 800 pb^{-1} of data at the $\psi(3770)$ and are planing to double the data sample recorded at $E_{cm} = 4170$ MeV, so there are still many interesting results to come from the CLEO-c data sample.
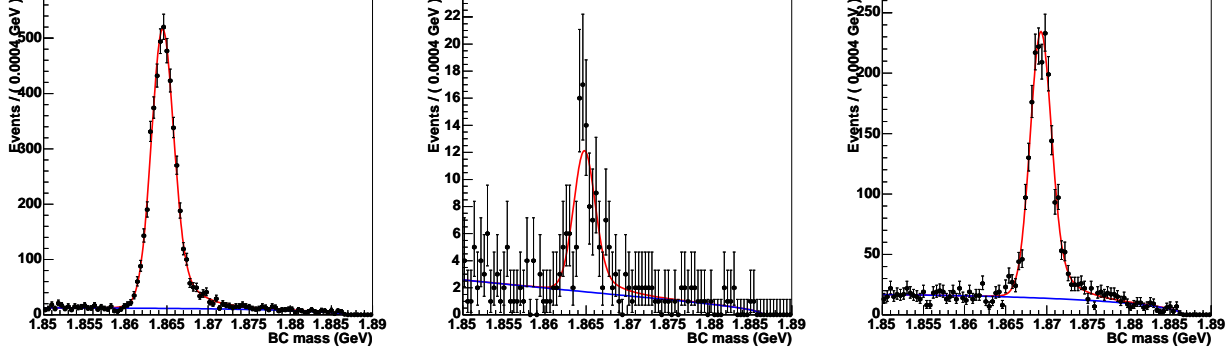
FIG. 6: From left to right the yields in the $D^0 \to K^+K^-$, $D^0 \to K_S^0 K_S^0$, and $D^+ \to K^+ K_S^0$ are shown. We observe 4747 ± 74, 96 ± 13, and 1971 ± 51 events respectively in these modes. For the $D^0 \to K_S^0 K_S^0$ analysis we subtract backgrounds, primarily, from $D^0 \to K_S^0 \pi^+ \pi^-$ and find 70 ± 15 signal events.

TABLE VII: Preliminary branching fractions obtained in the study of two-body Cabibbo suppressed decays of D mesons to pairs of kaons.

	Our Measurement (10^{-3})	PDG 2007 (10^{-3})
$\mathcal{B}(D^0 \to K^-K^+)$	$4.01 \pm 0.07 \pm 0.08 \pm 0.07$	3.85 ± 0.09
$\mathcal{B}(D^0 \to K_S^0 K_S^0)$	$0.149 \pm 0.034 \pm 0.015 \pm 0.03$	0.36 ± 0.07
$\mathcal{B}(D^+ \to K_S^0 K^+)$	$3.35 \pm 0.10 \pm 0.10 \pm 0.12$	2.95 ± 0.19

[1] S. Dobbs *et al.* (CLEO Collab.), arXiv:0709.3783v2 [hep-ex] (2007), Accepted for publication in Phys. Rev. D.

[2] R. M. Baltrusaitis *et al.* (Mark III Collab.), Phys. Rev. Lett. 56, 2140 (1986); J. Adler *et al.* (Mark III Collab.), Phys. Rev. Lett. 60, 89 (1988).

[3] W. Sun, Nucl. Instrum. Methods A556, 325 (2006).

[4] G. S. Huang *et al.* (CLEO Collab.), Phys. Rev. D**74**, 112005 (2006).

[5] S. A. Dytman *et al.* (CLEO Collab.), Phys. Rev. D**74**, 071102(R) (2006).

[6] B. Aubert *et al.* (BABAR Collab.), Phys. Rev. D**74**, 011107(R) (2006).

[7] I. I. Bigi and H. Yamamoto Phys. Lett. **B349**, 363 (1995).

[8] Q. He, et al *et al.* (CLEO Collab.), arXiv:0711.1463v1 [hep-ex] (2007).

[9] D.-N. Gao, Phys. Lett. **B645**, 59 (2007).

[10] G. S. Adams, et al *et al.* (CLEO Collab.), arXiv:0708.0139v1 [hep-ex] (2007), Accepted for publication in Phys. Rev. Lett.

[11] The result presented here represents the final results and are slightly different from the results presented at the workshop.